CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
SCOTTISH QUALIFICATIONS AUTHORITY
ON BEHALF OF THE
MARITIME AND COASTGUARD AGENCY

STCW 78 as amended MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)

040-31 - APPLIED MECHANICS

TUESDAY, 11 DECEMBER 2018

1315 - 1615 hrs

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook
Graph paper

APPLIED MECHANICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A four ram hydraulic steering gear has a maximum angle of helm limited to 35° from mid-position. The diameter of the rams is 325 mm and the distance from the centre of the rudder stock to the centreline of the rams is 800 mm. The relief bypass valves limit the oil pressure to 80 bar.

   (a) Explain, with the aid of a simple sketch, the principle of Rapson's slide in terms of hydraulic steering gear. (4)

   (b) Calculate the diameter of the rudder stock to limit the maximum torsional stress to 80 MN/m^2. (12)

2. A body is at rest on a plane inclined 10° above the horizontal. When a force of 1300 N is applied to the body parallel to the plane it just begins to ascend. The motion is replicated by a force of 1450 N applied to the same body horizontally, as shown in Fig Q2.

   Calculate EACH of the following:

   (a) the coefficient of friction between contact surfaces; (10)

   (b) the mass of the body. (6)

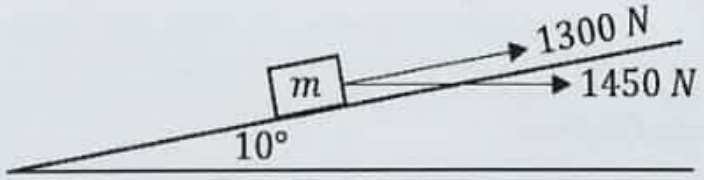

Fig Q2

3. A tanker is travelling due South at 19 knots. At 1200 hours the tanker observes a passenger ship 10.5 nautical miles due West heading south east at 21 knots.

   Calculate EACH of the following:

   (a) the relative velocity and apparent course of the passenger ship as seen from the perspective of the tanker; (8)

   (b) the distance of closest approach between these vessels; (2)

   (c) the approximate time at which closest approach occurs. (6)

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4. The calibration of a lifting machine with a velocity ratio of 45 produced the following results:

Effort (N)	305	415	525	635	746
Load (kN)	2	4	6	8	10

Table Q4

(a) Determine the law of this machine. (8)

(b) Calculate EACH of the following:

(i) the mechanical advantage using this machine to lift a load of 11 kN; (4)

(ii) the efficiency of this lifting machine for an applied effort of 400 N. (4)

5. An engine has a cam follower with a total travel of 60 mm operating a valve. The follower oscillates with simple harmonic motion taking 1.5 seconds to open and close the valve.

If the moving parts have a total mass of 40 kg, calculate EACH of the following:

(a) the velocity of the follower when the valve is four fifths open; (10)

(b) the acceleration of the follower at the same position; (4)

(c) the maximum inertia force. (2)

6. The winding drum of an electric hoist is 1.5 m diameter, has a radius of gyration of 0.6 m and rotating parts of mass 1415 kg. A mass of 575 kg is accelerated vertically at a rate of 0.5 m/s^2 using a wire cable. The friction torque at the bearings is a constant 190 Nm.

Calculate EACH of the following:

(a) the angular acceleration of the drum; (3)

(b) the moment of inertia for the drive and drum; (3)

(c) the total torque required to raise the load at this rate. (10)

7. A symmetrical beam, as shown in Fig Q7, is simply supported at either end. It carries a uniformly distributed load of 15 kN/m over its full length and a 2 kN point load at the mid-span position. The maximum permissible bending stress for the beam material is 60 MN/m^2.

Calculate EACH of the following:

(a) the second moment of area for the I-beam; (4)

(b) the maximum length of the beam for the stated conditions. (12)

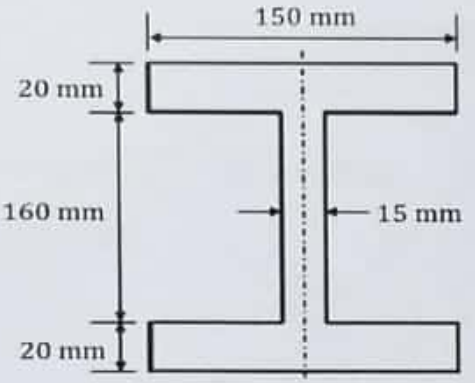

Fig Q7

8. A reciprocating engine transmits 4500 kW at 105 rpm via a directly coupled solid main shaft. The solid shaft is replaced with a hollow shaft fabricated from the same material. The maximum permissible stress within either shaft is 55 MN/m^2 and the ratio of mean to maximum torque is 1 to 1.25.

Calculate EACH of the following:

(a) the diameter of the solid main shaft; (6)

(b) the diameter of the hollow main shaft with a bore equal to half the outer diameter. (10)

9 A thin cylindrical pressure vessel is 1.25 m diameter with plate thickness 42 mm. The circumferential seams are vee welded at an angle of 60° as shown in Fig Q9. During operation the vessel is pressurised to 35 bar.

Calculate EACH of the following:

(a) the circumferential stress within the vessel; (3)

(b) the longitudinal stress within the vessel; (3)

(c) the normal tensile stress at the weld seam; (5)

(d) the shear stress at the weld seam. (5)

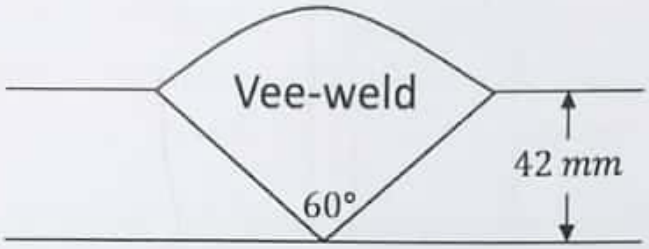

Fig Q9